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Packet Radio Temporary Note #179

NEW CAPABILITIES OF THE PACKET RADIO SIMULATION PROGRAM

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1. INTRODUCTION

New capabilities recently implemented in the packet radio simulation program are presented. The capabilities discussed include: packet acquisition model, error correction algorithm, variable packet and header sizes, processing time of headers, and measurements associated with these. Sample outputs are also presented. The models implemented were proposed and/or defined together with ARPA, SRI, and Maganavox.

In the past, much effort has been devoted to development of the program and implementation of new capabilities. The present version of the program includes many capabilities which have not been exploited for studies (e.g., initialization); and we plan to put emphasis on studies in the future.

2. NEW CAPABILITIES

2.1 Packet Acquisition and Bit Error Rates

An acquisition probability is associated with a received packet. Packet acquisition takes into account PLR + SLR, where:

PLR: packet sync was never acquired.

SLR: packet sync was acquired but bit sync dropped out before all bits were received.

Two values of (PLR + SLR) are used, one for the 100 Kb/s channel (default = 1.0%), and a second for the 400 Kb/s channel (default = .5%).

A Bit Error Rate (BER) is associated with an acquired packet. Rather then having BER as a function of received power, a fixed BER value is associated with a packet radio device (station, repeater, terminal). Hence, all packets received by a particular device have the same BER. BER values are coded into four levels which may correspond to the following environments: GOOD, FAIR, POOR, VERY POOR.

2.2 Error Correction Algorithm

A processing delay of running the error correction algorithm is implemented (default 4 msec). The probability of decoding a failure (implemented) is a function of:

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- Code Rate.
- Bit Error Rate.
- Packet Size.
- Number of times same packet has been acquired by the device.

Values for the probability of decoding a failure for code rates of 3/4, 1/2, and 1/4, for a packet size of 1000 bits were supplied by Maganavox.

2.3 Protocol Processing Delay

A processing delay which simulates the time for processing the packet header is implemented. A single value is used (default = 6 msec), independent of the amount of processing (e.g., whether device discards the packet or needs to modify its header for switching). One of the implications of this delay, for example, is that an active HBH ack cannot be transmitted immediately at the end of packet reception (when the channel may be idle), instead it is scheduled for transmission and needs to go through the channel access protocol.

2.4 Packet and Header Size

For packet text, there is a capability of having a variable size. The variable size is selected using a uniform distribution between a minimum and maximum value. The minimum size is used for control packets (e.g., Acks).

There are two header size values to simulate Intranet and Internet headers. Presently, it is assumed that all short packets have an intranet header. The two header sizes can be used simultaneously; a parameter specifies the fraction of intranet information packets.

For default values we are using 176 bits (128 + 48 preamble) for intranet header, and 304 bits (256 + 48 preamble) for internet header.

2.5 Measurements

To evaluate the error model we measure, for every device, the following items:

1. Number of packets acquired.

2. Number of packets lost due to sync loss or sync not acquired.

3. Total number of times a packet was not corrected.

4. Number of packets corrected by the error correction algorithm.

5. Number of packets discarded, i.e., device unable to correct.*

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* A time-out is associated with the reception of every packet that a device is unable to correct, waiting for a retransmission of same. A packet is discarded when time out expires. Hence, at heavy traffic, packets may be discarded before another copy is received.

6. Maximum number of buffers used by the device for storing packets waiting for correction.

7. Number of packets discarded due to buffer unavailability.

Other measurements recently added to the simulation program include:

1. Histogram of number of packets in entire repeater net waiting for transmission (does not take into account buffers of uncorrected packets).

2.* Average number of retransmissions in the direction TO station. This is given by device and by hierarchy level.

3.* Same as 2. in the direction FROM station.

4. Peak buffer usage of various queues in the station.

5. Terminal blocking times. This is shown in the plotted output.

2.6 Implementation Comments

The error correction model required increasing buffer capacity of devices. In the program, buffers are not permanently assigned to devices for this purpose; instead, symbolic buffers are given to a device only for the duration of use for error

*These values can be used to observe bottlenecks.

correction. The buffers are from the pool of packets "in the air" waiting for delivery to devices. The maximum number of buffers assigned to devices for this purpose can be specified; default values used are 9, 4, and 4, for station, repeater, and terminal, respectively.

The new capabilities required significant changes in many of the subroutines, and the addition of new subroutines (six new subroutines were added to accommodate packet aquisition and error correction). Furthermore, various operating parameters need to be "optimized" when error correction and/or protocol processing delays are used. For example, time-outs for HBH and ETE retransmissions must take into account the additional delays, so does the time-out for waiting for another copy of a packet to enable correction.

3. SAMPLE OUTPUTS

The results presented are aimed to demonstrate the new capabilities of the program. In fact, one may observe that the system is overloaded. Three runs were performed; one with zero protocol processing delay and no capture or bit errors; and two runs with code rates of 1/4 and 1/2. The two runs with errors assume the same BER of 10% for all devices. The offered rate for all runs was 20% (of 100 Kb/s) and the traffic was composed of 80% Internet packets (304 bit header). Other parameters related to the new capabilities were the default values.

Figure 1 shows the topology of the network and Figures 2 through 4 show the plotted output for the three runs. Regarding the plotted output, it is noted that:

1. The values of offered rate, input rate, and throughput are for Text Bits only and do not include Header Bits. Hence, the throughput represents ETE acknowledged information bits. Neither do these values include control packets; such as ETE Acks, and those of the search protocol by terminals to identify a repeater.

2. The values are not scaled by the Code Rate; hence, to obtain net information bits one has to multiply by the code rate.

3. The triangles on the horizontal axis indicate the times that a terminal was blocked.

Table 1 summarizes other performance measures for the three runs. Note the consistency of the measures of the error correction algorithms associated with the code rates.

1	2	3	4	5	6	7	8	9	10
CODE RATE	AVERAGE ROUND TRIP PACKET DELAY [MSEC]	AVERAGE NUMBER OF BUFFERS OCCUPIED IN REPEATER NET	PEAK BUFFER USAGE AT STATION FOR INFORMATION PACKETS TO TERMINALS	NUMBER OF PACKETS ACQUIRED	PACKETS DISCARDED (SYNC NOT ACQUIRED OR LOST)	TOTAL NUMBER OF TIMES PACKET WAS NOT CORRECTED	NUMBER OF PACKETS EVENTUALLY CORRECTED	NUMBER OF PACKETS DISCARDED (BER LOSS)	NUMBER OF PACKETS DISCARDED DUE TO BUFFER UNAVAILABILITY
1	400	6.26	37	-	-	-	-	-	-
1/2	845	7.87	62	11,792	88	78	56	21	8
1/4	904	9.30	54	9,500	87	10	5	5	5

TABLE 1: PERFORMANCE MEASURES. ITEMS 5 THROUGH 10 ARE FOR ALL REPEATERS AND THE STATION. SAME VALUES FOR TERMINALS ARE AVAILABLE.

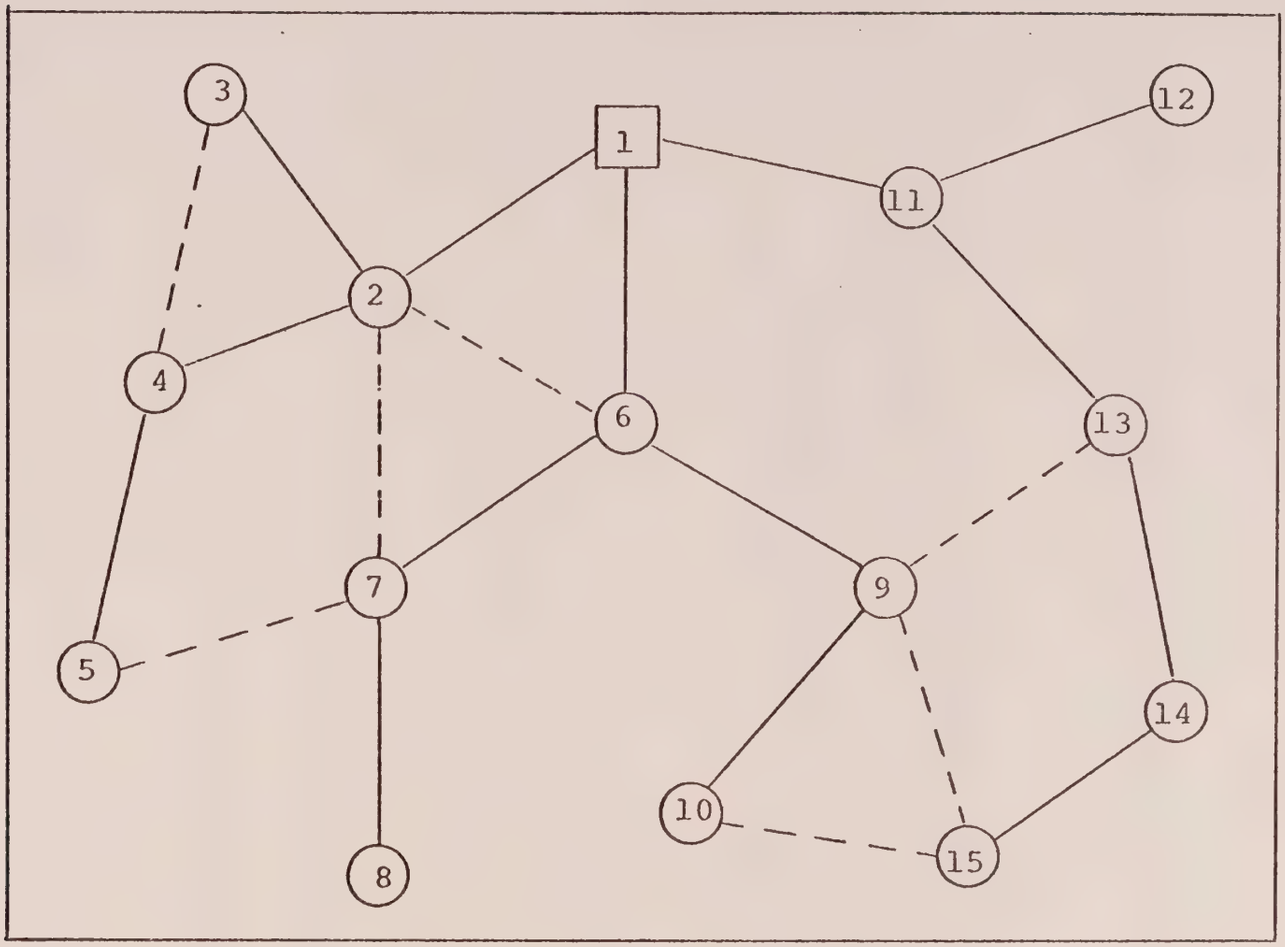

FIGURE 1: NETWORK TOPOLOGY. SOLID LINES INDICATE LINKS USED FOR ROUTING.

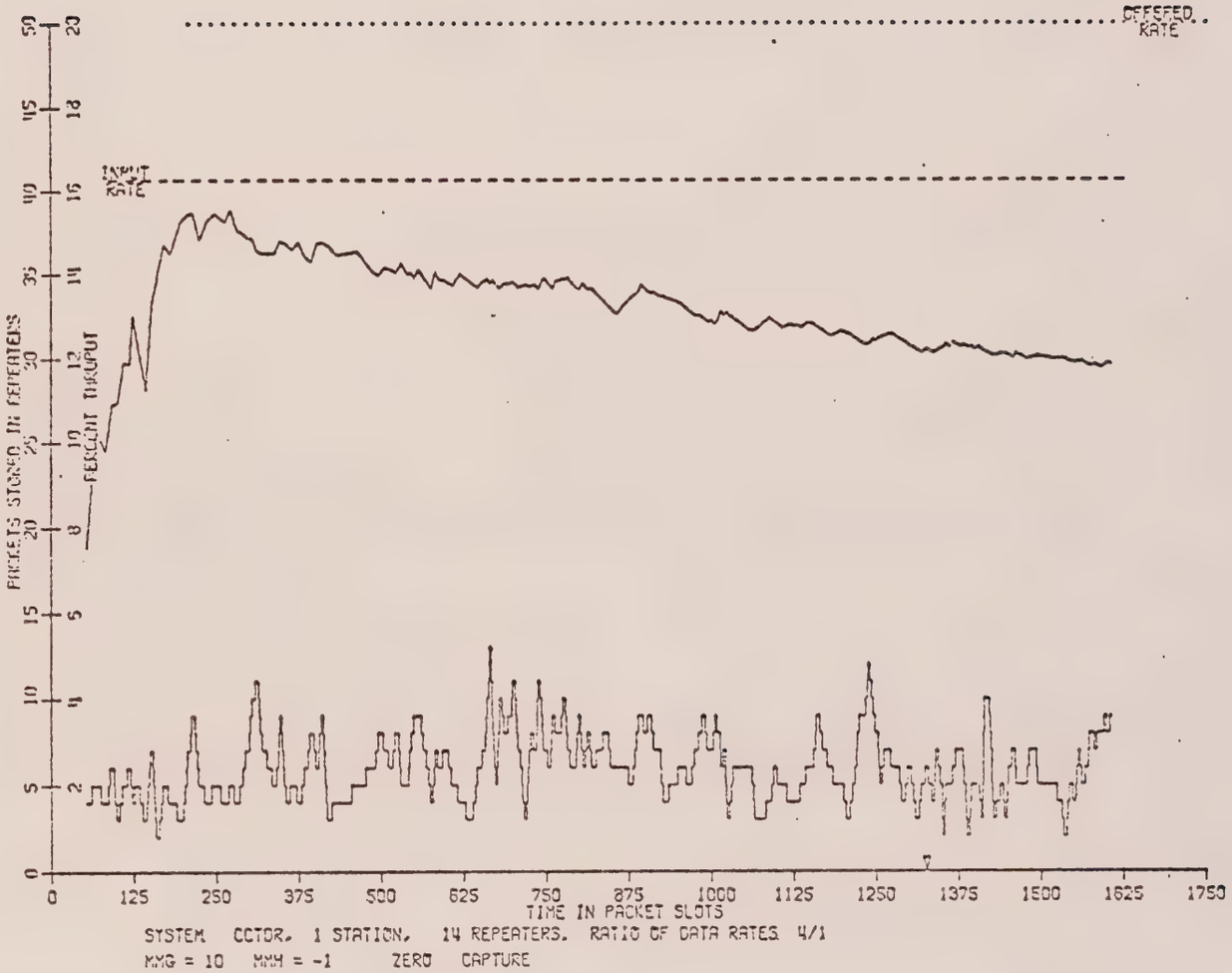

FIGURE 2: OUTPUT FOR RUN WITHOUT ERROR MODEL AND PROTOCOL PROCESSING DELAY

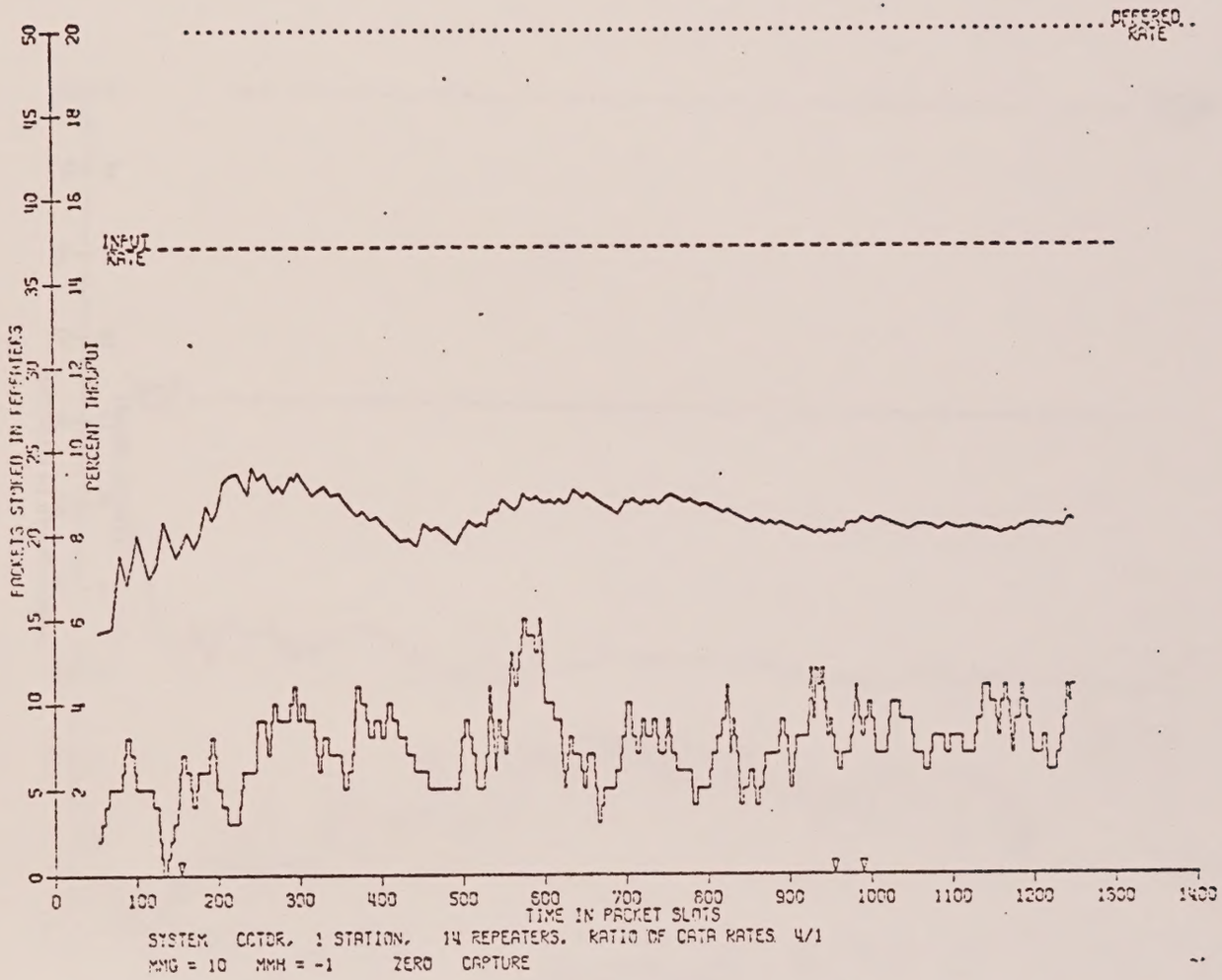
OFFERED RATE
INPUT RATE
PACKETS STORED IN REPEATERS
PERCENT THROUGHPUT
TIME IN PACKET SLOTS
SYSTEM OCTOR, 1 STATION, 14 REPEATERS. RATIO OF DATA RATES 4/1
MMG = 10 MMH = -1 ZERO CAPTURE

FIGURE 3: OUTPUT FOR RUN WITH CODE RATE OF 1/2

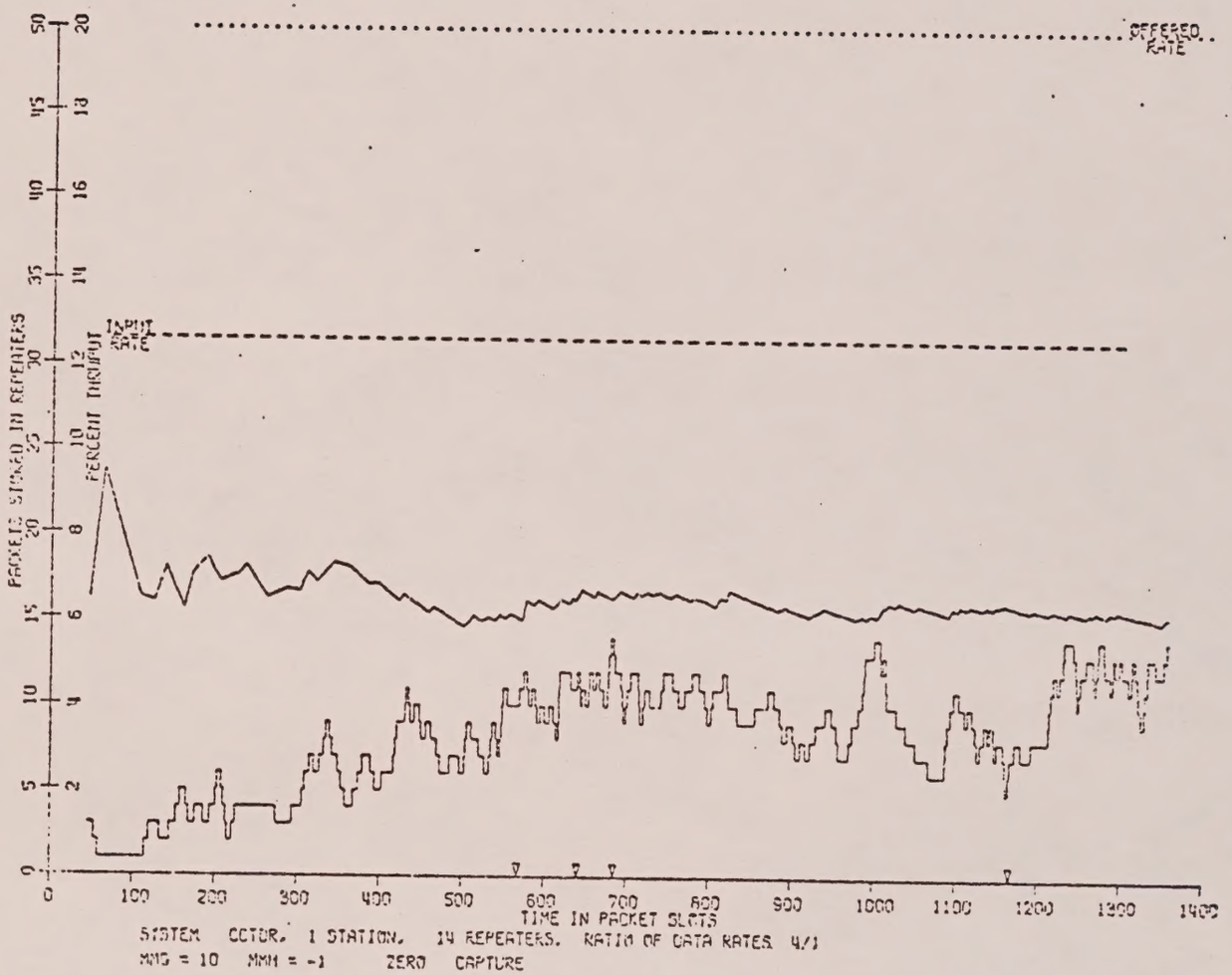
OFFERED RATE
PACKETS STORED IN REPEATERS
PERCENT THROUGHPUT
TIME IN PACKET SLOTS
SYSTEM OCTOR, 1 STATION, 14 REPEATERS. RATIO OF DATA RATES 4/1
MNG = 10 MMM = -1 ZERO CAPTURE

FIGURE 4: OUTPUT FOR RUN WITH CODE RATE OF 1/4